Nationwide tsunami during prehistoric Maori occupation, New Zealand

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Abstract. A summary of evidence for nationwide tsunamis in about the mid-15th century AD is given from coastal sites, including archaeological sites, on the east and west coasts of New Zealand. The tsunamis are about the same age as a cluster of more than four large earthquakes, many with a component of submarine rupture. The archaeological record shows breaks in the occupation of sites, either temporary or permanent, at about the same time. While there are other known clusters of large earthquakes and associated tsunamis prior to this event, the mid-15th century tsunamis are the only ones currently known to have affected prehistoric Maori settlements. Bearing in mind the short time that paleotsunami research has been undertaken in New Zealand, and the limited number of sites studied so far, the country appears to offer considerable scope for detailed work.

1. Introduction

New Zealand has a tectonically active landscape and a ca. 700-year history of human settlement. Seismic activity has several times caused widespread regional disruption following European settlement less than 200 years ago (e.g., 1855 AD Wairarapa earthquake (Grapes and Downes, 1997), 1931 AD Napier earthquake (Hull, 1986), and 1947 AD Gisborne tsunamis (Eiby, 1982)) (Fig. 1), and there are rare accounts in Maori oral traditions that appear to refer to earthquakes and tsunamis (e.g., Best, 1918).

In the records of all coastal areas studied to date one period of tsunami inundation is prominent in the sedimentary evidence. Whether there was one or a cluster of tsunamis is unknown, but the period probably reflects several events that affected the whole coastline. For the purposes of this paper the events are referred to as a single event. The event occurred around the mid-15th century AD (e.g., Goff and Chagué-Goff, 1999; Goff and McFadgen, 2001; Goff *et al.*, 2000). Its tsunamigenic source was initially assigned to the last rupture of the Wellington fault, although it has been linked more recently with a rupture of the Alpine fault (Chagué-Goff and Goff, 1999; Goff *et al.*, 2000) (Fig. 1). Other fault ruptures at about the same time include the Hope fault (Cowan and McGlone, 1991), the Palliser-Kaiwhata fault (Barnes and Audru, 1999; Berryman *et al.*, 1989), and the Napier Syncline complex (Hull, 1986) (Fig. 1). All ruptured as large (>7.5 M_w) earthquakes and are potential initiators of tsunami events. They are by no means the only potential initiating events around the 15th century AD; the phreatic Rangitoto eruption, for example, dates to about this time (McFadgen, 1981) (Fig. 1).

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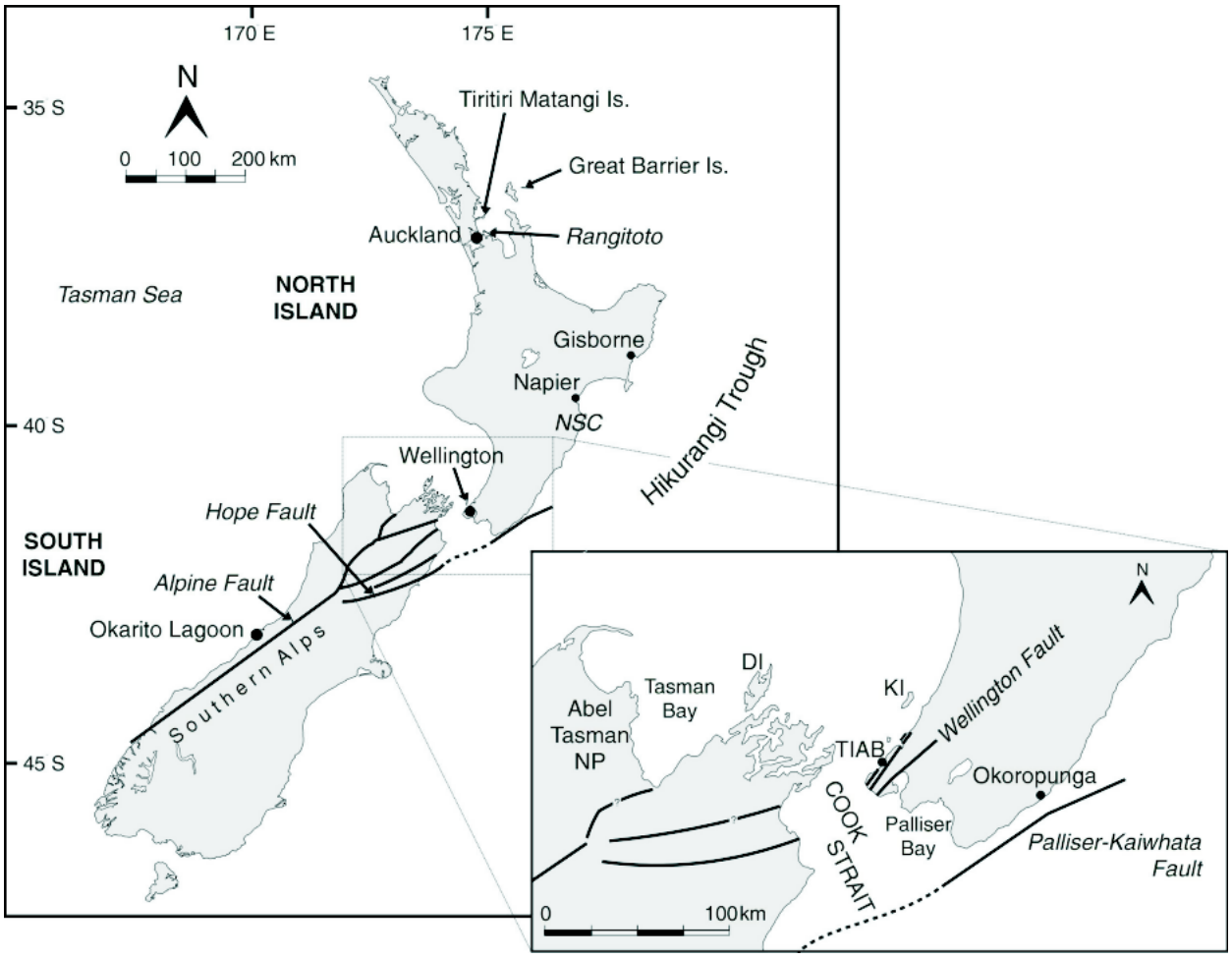

Figure 1: Map of New Zealand showing place names and features mentioned in the text. Fault line locations have been simplified to include only those discussed; *NSC*—Napier Syncline Complex, DI—D'Urville Island, KI—Kapiti Island, and TIAB—Te Ikaamaru Bay.

While the full extent of ruptures on the faults listed above is not known, the Alpine fault has a submarine component as do the Wellington and Hope faults, the Palliser-Kaiwhata fault (a possible extension of the Hope fault—Barnes and Audru, 1999) is entirely submarine, and the Napier Syncline Complex is coastal and adjacent to the active subduction zone of the Hikurangi Trough (Fig. 1). It is therefore likely that most, if not all, of these ruptures could have propagated tsunamis, or else submarine landslides that in turn could have propagated tsunamis.

2. Evidence for a Mid-15th Century AD Paleotsunami

There are two sources of evidence: the sedimentary record of inundation of coastal environments, and breaks in the occupation of coastal archaeological

sites. The first comprehensive multiple-tsunami study was carried out in Abel Tasman National Park at the northern end of the South Island (Goff and Chagué-Goff, 1999) (Fig. 1). Of the four events identified the most marked, recognizable tsunami deposit was found at all sites studied and was dated to the mid-15th century AD. At the time the work was done, no prehistoric Maori settlements were known to have been affected. Since then, however, we find that at D'Urville Island on the eastern side of Tasman Bay (Fig. 1), Wellman (1962) reports a layer of coarse gravel and sand at Greville Harbour that underlies the older of two occupation layers and thins toward the hills behind the beach. Wellman (1962) thought that the pebbles had been dropped by Maori carrying gravel to their gardens. An alternative possibility is that the pebbles are a tsunami deposit but they have not yet been re-examined to test this possibility. The stratigraphic position of the pebbles (McFadgen, 1985) suggests probable deposition in about the 15th century AD.

The mid-15th century AD tsunami deposit found in the inlets of Abel Tasman National Park was larger than that of the historical 1855 AD event (Chagué-Goff and Goff, 1999; Goff and Chagué-Goff, 1999; Lowe and De-Lange, 2000). Wave heights of the 1855 AD tsunami were up to 10 m high in Cook Strait and it can be assumed that the mid-15th century AD event was larger. Mid-15th century AD tsunami deposits found at the northern end of Kapiti Island indicate an estimated minimum wave height, based on the morphology of the site, of 11–15 m (Goff *et al.*, 2000) (Fig. 1).

Recent research associated with archaeological sites adds to the Cook Strait tsunami data and extends the evidence further afield. At Te Ikaamaru Bay, marine deposits consisting of a poorly stratified unit of pebbles and coarse sand overlie alluvial deposits up to 200 m inland (Fig. 1). While originally interpreted by one of the authors (BGM) as an anthropic soil, a recent reinterpretation suggests that this is possibly a tsunami deposit. It is stratigraphically older than 1855 AD tsunami deposits, post-dates Maori settlement, and most likely relates to inundation around the mid-15th century AD (Goff and McFadgen, 2001).

A more wide-ranging reinterpretation of archaeological data is based on the detailed work reported by Leach and Leach (1979), whose work contains considerable archaeological and environmental evidence for the abandonment of coastal settlements in Palliser Bay (Fig. 1). However, while the abandonment was originally thought to be a result of climatic events and human-induced environmental changes (Leach and Leach, 1979), Goff and McFadgen, (2001) reinterpret it as a response to the aftermath of major seismic activity including tsunami inundation.

There are numerous archaeological sites along the low-lying coastal platform of New Zealand and evidence is starting to emerge of similar inundations elsewhere. Three examples come from the east coast of the North Island. Tiritiri Matangi Island, off the northeast coast of Auckland (Fig. 1), was a low-lying coastal platform site of early Maori settlement some 700 years ago. Archaeological work carried out in the mid-1980s identified an abandonment of the site, possibly for more than a hundred years. Based upon stratigraphic and archaeological evidence, and comparison with other

sites in the region, the abandonment is thought to have occurred in the latter part of the 15th century AD (R. Brassey, personal communication, 2000). The upper surface of the first occupation layer had an erosional contact with a beach gravel unit about 10 cm thick containing pieces of rock apparently ripped up from the coastal platform. The unit was originally assigned to a storm deposit, but it appears to have been a single event not subsequently repeated and may be related to tsunami inundation propagated by the phreatic Rangitoto eruption a few kilometers south of the site.

From elsewhere in the Auckland region Nichol *et al.* (2000) report sedimentary evidence for a single, high-energy coastal event on the east coast of Great Barrier Island (Fig. 1), about 60 km northeast of Tiritiri Matangi Island. They describe a widespread veneer of pebbles and cobbles, one clast thick, that extends for about 250 m landward, from the toe of the foredune, to a maximum elevation of 14 m above the present berm. The total area of exposed gravel is about 30,000 m^2. Radiocarbon analysis of two articulated bivalves taken from a reworked Maori midden within the gravel field date to the mid-15th century AD and it is highly likely that Maori were present in the area when the tsunami struck (Nichol *et al.*, 2000).

Further south, and northwest of Palliser Bay, a Maori garden site at Okoropunga bears surface features we tentatively interpret as resulting from tsunami inundation (Figs. 1 and 2). Between the inland and seaward stone rows are a partly infilled borrow pit and stone rows that are partly or totally buried. Near the back of the coastal platform is a sheet of sand estimated to be between 300 and 500 years old (McFadgen, 1980).

Paleotsunami research is currently being carried out at Okarito Lagoon on the West Coast of the South Island (Fig. 1). The uppermost of a series of buried soils is overlain by a laterally extensive fining-upwards sequence that has been traced 2.5 km inland (Fig. 3). Articulated bivalves in the sequence date to the mid-15th century AD (S. Nichol, personal communication, Feb. 2001). The remains of a buried Maori village were reported at the northern end of the site by early explorers (Brunner, 1952).

Ongoing research being undertaken by the authors on the east coast of the South Island reexamines archaeological sites and site data. Initial results indicate that there are three groups of prehistoric Maori coastal settlements; early occupation sites abandoned by about the mid-15th century AD, later occupation sites commencing in the late-15th century AD, and long term occupation sites with a temporary abandonment phase about the mid-15th century AD (Challis, 1995). Two site examinations can be reported to date, one temporary abandonment where the occupation layers are separated by a pebble unit that is one clast thick; the other an early occupation site overlain by a fining-upward sequence of pebbles and sand.

3. Evidence Beyond New Zealand?

An event (or events) of the magnitude discussed in this paper would presumably have had an impact beyond New Zealand. If a large enough seismic event occurred, evidence for a tsunami could be expected on the east coast

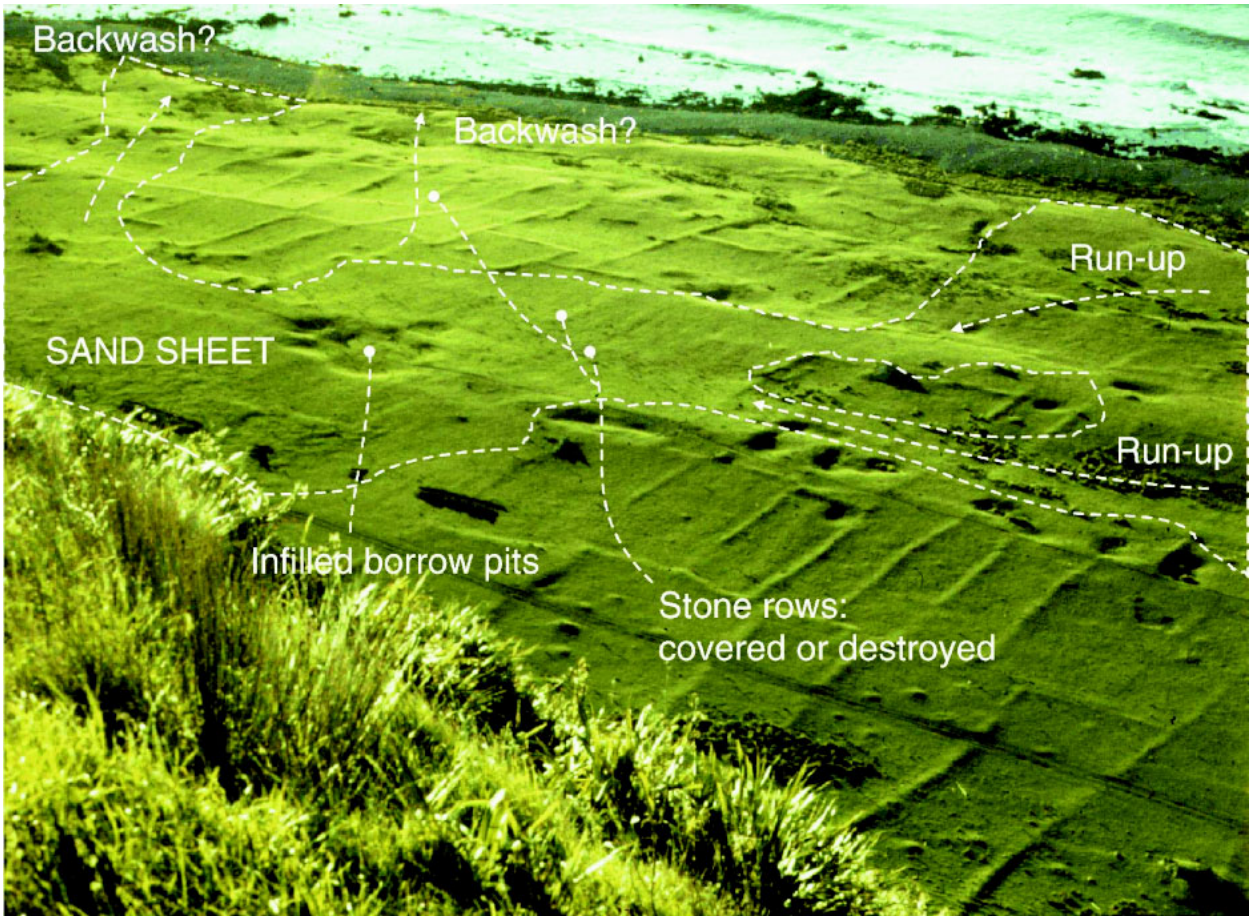

Figure 2: Okoropunga. Stone row garden system and borrow pits situated on uplifted shorelines (Photo: Graham Billing). Geomorphological interpretation shown by dashed lines.

of Australia and on islands in the southwest Pacific. While such an event may alone generate sufficient submarine offset to propagate a Tasman-wide tsunami, it would also undoubtedly generate numerous submarine landslides off the continental shelf.

Evidence of tsunamis beyond New Zealand in or about the 15th century AD is reported from the east coast of Australia, and several coastal midden sites reworked by seawater in the Sydney area date to this period (Bryant *et al.*, 1992; Fullagar *et al.*, 1999; Nott, 1997). The evidence is compelling, but requires further investigation to see whether it relates to the mid-15th century AD event in New Zealand.

4. Discussion and Conclusions

A cluster of large earthquakes in and around the mid-15th century AD appears to have generated a nationwide signal of tsunami inundation. The earthquakes are unlikely to have been synchronous, but within a short period of time the whole coastline of the country appears to have been affected.

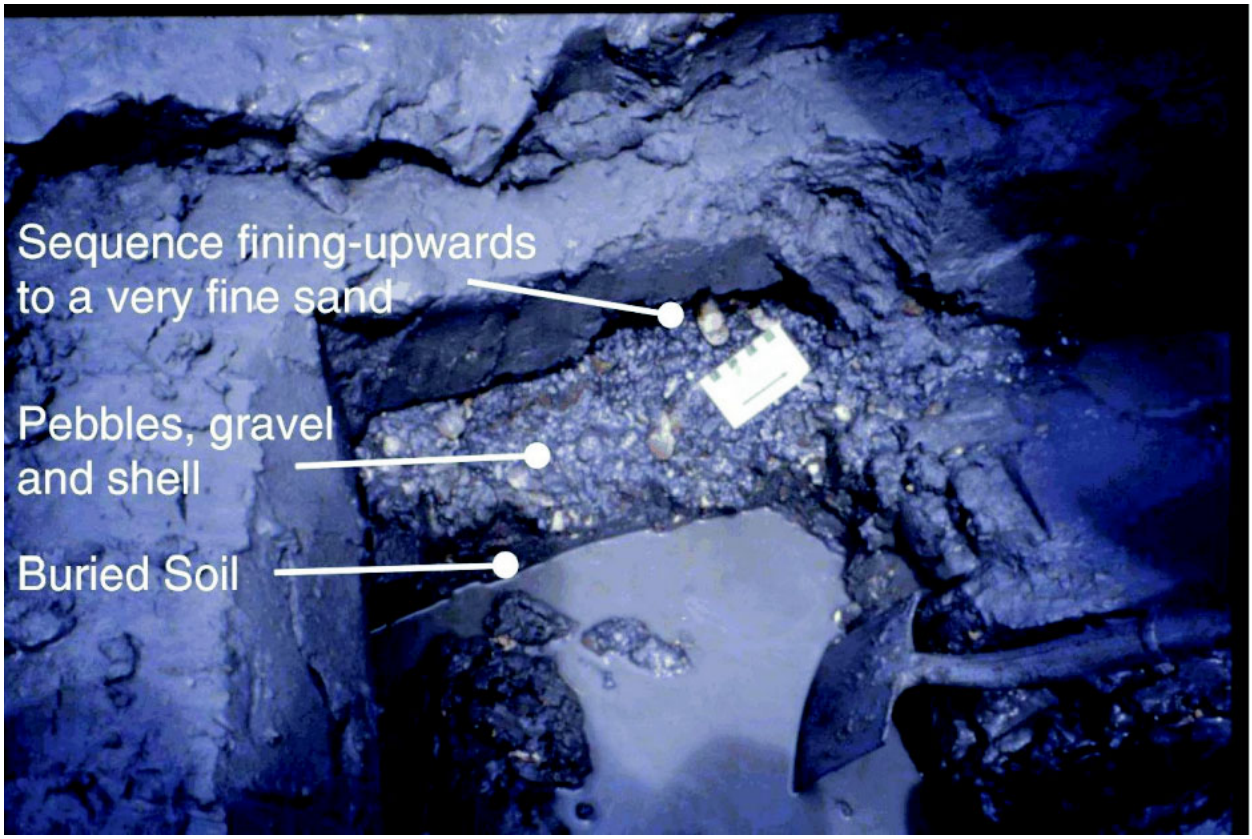

Figure 3: Okarito Lagoon. "The Dog's Breakfast deposit"—The uppermost of a series of buried soils, overlain by a fining-upwards sequence (pebbles to very fine sand) including articulated and broken shells (Photo: Scott Nichol).

Much of the coastline had been settled by Maori at the time, mainly in bays and along the coastal platform. We note that a response of some prehistoric coastal Maori to tsunami inundation (and in most cases it was probably also a response to the cumulative aftereffects of a large earthquake) was a temporary or permanent abandonment of sites. The timing of abandonment coincides approximately with a movement in some places from bays and coastal platforms to hills and inland sites (Jacomb, 2000; Leach and Leach, 1979; Wellman, 1962). Furthermore, it comes at a time of cultural change from the Archaic to the Classic period, and at the onset of warfare and hill fort (pa) construction (e.g., Jacomb, 2000).

There are numerous archaeological sites in the bays and on the low-lying coastal platform of New Zealand. This exposure makes it likely that past tsunamis will have had an effect on the prehistoric occupation of these areas. It is important that further fieldwork is undertaken around the coastline of New Zealand, not only in archaeological settings, but also in coastal wetlands and other sites. Similar clusterings of large earthquakes occurred prior to the mid-15th century AD and there is a growing database of information

for similar nationwide tsunami inundation prior to human occupation (e.g., Goff and Chagué-Goff, in press).

Acknowledgments. We would like to thank all those funding agencies that have supported, and continue to support, our work. This paper is a contribution to IGCP Project 437 "Coastal Environmental Change During Sea-Level Highstands".

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